MISO LUO POSITIVE OUTPUT DC-DC CONVERTER FOR SUSTAINABLE ENERGY APPLICATIONS

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Abstract- Renewable energy resources have astonishing capabilities to fulfill ever increasing future demands. Changing climatic conditions is a major inherent drawback associated with it and MPPT (Maximum Power Point Tracking) is one of the techniques used to overcome it (wind and solar). This paper has proposed a positive output super lift Luo converter which is integrated with multiple sources for reducing passive elements. The proposed topology can be used for low or high power applications and can be extended to interface any number of sources having different characteristics. In case used for renewable sources’ grid integration, number of active switches required will be only two for any number of sources. It also has a bidirectional battery storage port that improves reliability of the system. These systems are simulated in MATLAB software environment and results are obtained.

Keywords- Luo converter, MISO Luo converter, Bidirectional battery port, MPPT, Renewable energy sources

I. INTRODUCTION

The voltage-lift (VL) technique is a popular method used in electronic circuit design. This technique was also used in DC-DC converters to boost the source voltage into a higher level with high power efficiency and high power density due to reduced effect of parasitic element. The positive output super lift Luo converter is a DC-DC converter having high voltage transfer gain, high power density, high efficiency, reduced ripple in voltage and current. These converters are widely used in computer peripheral equipment, industrial applications and switch mode power supply, especially for high voltage applications.

A positive output Luo converter for photovoltaic system with model predictive control algorithm is designed and simulated in. The super lift converter for photovoltaic system is designed and simulated for AC load and grid in. A solar panel power system is designed using the super lift Luo converter with a closed loop control to obtain the desired output voltage in. However, number of passive elements goes on increasing as number of sources increase making system bulky and cost inefficient.

Solar-Wind based Dual-Input Converter is proposed for telecom applications in. A three-input DC-DC boost converter with bidirectional battery interface is proposed in. However, topologies in are not extendable to more number of input sources. MISO (Multiple Input Single Output) systems based on flux addition concept are proposed in. As the number of sources increases, system becomes difficult to handle. Different MISO topologies are developed for sepic and cuk converter in. As number of sources goes on increasing the circuit components are added linearly (especially control switches). Some topologies should have all sources at same voltage level. A MISO DC-DC converter along with its control scheme is proposed and analyzed in. It requires large number of passive elements. Proposes a novel half bridge converter based topology that interfaces four power ports: two sources, one bidirectional storage port, and one isolated load port. While connecting multiple renewable sources, it cannot extract maximum power from each source and it is only suitable for low-power applications since it has half-bridge topology. Proposes new extendable single-stage multi-input boost converter which can operate in both DC–DC and DC–AC modes and has two bidirectional ports for battery storage. This topology not only fails to provide common ground to source and load but also becomes complex when it handles three phase load. Modeling and simulation of Solar PV system with perturb and observe MPPT algorithm is studied in. In a VSWECS (Variable Speed Wind Energy Conversion System) with MPPT is considered.

This paper has proposed a positive output super lift Luo converter which is integrated to interface multiple sources for reducing passive elements. The proposed topology can be used for low or high power applications and can be extended to interface any number of sources having different characteristics. In case used for renewable sources’ grid integration, number of active switches required to interface any number of sources will be two only. It also has a bidirectional battery storage port that can be charged from any source while supplying load or discharge with any source and hold energy for future utilization.

This paper is structured as follows. Section II describes basic concept of positive output super lift Luo converter. Section III discusses working of MISO positive output super lift Luo converter. Section IV gives operating modes of MISO positive output super lift Luo converter with battery port. Section V discusses renewable energy sources taken into consideration i.e. wind and solar. Section VI contains simulation results. Section VII gives conclusion of the proposed system.

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II. POSITIVE OUTPUT SUPER LIFT LUO CONVERTER

Fig. 1 shows the basic topology of positive output super lift Luo converter. It has two operating stages depending on switching state of SW1.

In stage 1, when the switch is closed, the supply voltage increases the current through the inductor $L_1$ and the capacitor $C_1$ gets charged. The load current is maintained constant by the discharge of the capacitor $C_0$ during this period, as shown in Fig. 2.

In stage 2, when the switch is opened, the stored energy in the inductor $L_1$ and $C_1$, along with source 1, supplies the load current and $C_0$ is charged to produce the boosted voltage across the load, as shown in Fig. 3.

III. MISO POSITIVE OUTPUT SUPER LIFT LUO CONVERTER

The Luo converters are connected in such a way that the output side capacitor remains common. A diode and inductor are kept individual for each source. Charging capacitor is common for all sources connected above each other. E.g. $C_1$ is common for source 1 and source 2, as shown in Fig. 4.

In stage 1, when controlled switches are closed, diodes $D_2$, $D_3$, $D_5$, and $D_6$ are turned on. Source voltage charges parallel combination of inductor and capacitor. E.g. source 1 charges $L_1$ and $C_1$ whereas source 2 charges $L_2$ and $C_1$. The output stage capacitor $C_0$ supplies load current, as shown in Fig. 5.

In stage 2, when controlled switches are opened, diodes $D_1$ and $D_4$ are turned on. Energy stored by all passive elements, along with sources, is dumped in output stage capacitor $C_0$. So the output voltage is boosted, as shown in Fig. 6.
IV. MISO POSITIVE OUTPUT SUPER LIFT LUO CONVERTER WITH BATTERY PORT

The proposed multiple input Luo converters can be integrated with battery in such a way that the overall system can stand alone. Fig. 7 shows MISO Luo converter with two sources and one bidirectional battery port. However, this topology can be extended to interface any number of sources in addition to one bidirectional battery port.

We propose three working modes of the system.
1. Sources are supplying load without battery interference  
2. One or both the sources are charging battery  
3. Battery is discharging with one or both the sources

In the proposed circuit, SW1 and SW2 are operating switches. SW3, SW4 are control switches that decide operating mode of the circuit. Every mode has two stages that are defined by the conditions of SW1 and SW2. When SW1 and SW2 are on, the circuit works in stage A. When SW1 and SW2 are off, circuit works in stage B.

A. Mode 1
Here SW4 is turned on. D5 is forward biased by source voltages. In stage A, source 1 charges L1 and C1 whereas source 2 charges L2 and C2. Co supplies load power. In stage B, L1, C1 and L2, C2, along with sources, discharge in Co and we get boosted voltage across load. Here battery is neither charged nor discharged and hence retains its state of charge. This state can be fully charged where it can supply load power in case of emergency. This mode can also be realized using SW3 and D6. Fig. 8 shows active part of proposed circuit for mode 1.

B. Mode 2
Here only D3 and D6 conduct. SW3 and SW4 are turned off.

In stage A, source 1 charges L1 and C1 through battery whereas source 2 charges L2 and C2 through battery. Co supplies load power.
In stage B, L1, C1 and L2, C2, along with sources, discharge in Co and we get boosted voltage across load. Battery retains energy stored.
Here both the sources charge battery. Even if one source is inactive, the other source can charge battery. Fig. 9 shows active part of proposed circuit for mode 2.

C. Mode 3
Here SW3 and SW4 are turned on. D5 and D6 are reverse biased by battery voltage. In stage A, source 1 charges L1 and C1 whereas source 2 charges L2 and C2. Battery is also discharged in L1, L2 and C1, C2 as it comes in series circuit. Co supplies load power.
In stage B, L1, C1 and L2, C2, along with sources, discharge in Co and we get boosted voltage across load. Here battery is discharged to load when sources do not have enough energy to drive it. This mode also works when one of the sources is inactive. Fig. 10 shows active part of proposed circuit for mode 3.
I. RENEWABLE ENERGY SOURCES (WIND AND SOLAR)

D. Solar source and its MPPT
A prime attraction of PV systems is that it produces electrical energy by directly transforming a free renewable source of energy into electrical energy. The efficiency of solar cells depends on many factors such as temperature, insolation, spectral characteristics of sunlight, shadow, and so on.

All MPPT methods follow the same goal which is maximizing the PV array power output by tracking the maximum power in every operating condition. In this algorithm a slight perturbation is introduced in the system. This perturbation causes the power of the solar module to change. If the power increases due to the perturbation (dP/dV is positive) then the perturbation is continued in same direction. After the peak power is reached the power at the next instant decreases (dP/dV is positive) and hence after that the perturbation reverses as shown in Fig. 11. When the steady state is reached the algorithm oscillates around the peak point. In order to keep the power variation small the perturbation size is kept very small. It is observed that there some power loss due to this perturbation also the fails to track the power under fast varying atmospheric conditions. But still this algorithm is very popular and simple [14].

E. Wind source and its MPPT
Wind energy is a renewable, clean, and free energy source for energy production. Wind energy conversion system (WCES) requires no connection to an existing power source, and they could be combined with other power sources to increase system reliability and could be installed and upgraded as wind firm; more wind turbine could be added as power demand increases. The overall system cost can be further reduced by optimal control of high efficiency power electronic converters to extract maximum power in accordance with atmospheric conditions.

MPPT of the WTG (Wind Turbine Generator) ensures that it operates at the maximum value of Cp as shown in Fig. 12. One of the methods of estimating the maximum power point is by knowing the wind turbine parameters and measuring the rotational speed of the rotor. It is also possible to determine maximum power point without the knowledge of turbine parameters as well as rotor speed. In this scheme, the rotational speed of the generator is dynamically modified in accordance with magnitude and direction of active power flow [15].
sources. One solar and one wind source are made inactive after three seconds. Fig. 13 shows the solar insolation input given to solar sources. Fig. 14 shows the temperature input given to solar sources. Fig. 15 shows the wind speed input given to wind sources. The values of circuit components used for simulation are as follows: \( L_{\text{ALL}} = 3\text{mH}; C_{\text{ALL}} = 1\text{mF}; C_{o} = 5\text{mF}; \) switching frequency = 1 kHz; \( R \) (Load) = 30 Ohm.

Fig. 16 shows the scaled output current, voltage, power of the system. The output plot given is scaled as follows: Power is scaled as 1:1000. Voltage is scaled as 1:100. Current is scaled as 1:10.

**G. MISO Luo converter with battery**

The circuit is simulated for two sources - one wind and one solar. Insolation input to the solar source is 1000 W/m\(^2\). Temperature input given to the solar source is 35 °C. Wind speed input given to the wind source is 12 m/s.

The values of circuit components used for simulation are as follows: \( L_{\text{ALL}} = 3\text{mH}; C_{\text{ALL}} = 1\text{mF}; C_{o} = 5\text{mF}; \) switching frequency = 1 kHz; \( R \) (Load) = 30 Ohm. Battery source is rated at 150 V, 15 Ah.

The topology is operated in mode 1 for 0-2 sec; operated in mode 2 for 2-4 sec; operated in mode 3 for 4-6 sec.

Fig. 17 shows the scaled output current, voltage, power of the system. The output plot given is scaled as follows: Power is scaled as 1:1000. Voltage is scaled as 1:100. Current is scaled as 1:10. Fig. 18 shows variation in battery parameters i.e. voltage, current and initial state of charge (ISOC).

**CONCLUSION**

A new multiple input single output luo converter based topology is proposed and simulated in this paper. It is also integrated with bidirectional battery port.

It can be extended to interface any number of sources having different characteristics and voltage levels.
High power handling capability, reduced number of passive elements and least number of active switch requirements makes it a highly considerable choice for standalone grid integration of renewable energy sources.

REFERENCES


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